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ESCAP Regional Energy Development Programme (REDP)
Regional Network for Small Hydropower (RN-SHP)

Technical Advisory Group (TAG)
First Meeting

Hangzhou, China, 11 - 13 December 1984

REGIONAL NETWORK FOR SMALL HYDROPOWER
CONSULTATION MISSION REPORT*

Prepared by

Interim Co-ordinator of the
Regional Network for Small Hydropower

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V.85-21843

Mission members

Zhu Xiaozhang, Director of HRC, Interim coordinator, RN-SHP Secretariat

Chang Eugene, Assistant to the Director, TOKTEN Consultant

Wang Qi (Ms), Acting Head, External Liaison Division, HRC; Staff Assistant, RN-SHP Secretariat

RN-SHP Focal Points visited and host organisations

1. Oct.26--Nov.1 : National Energy Administration (NEA), Bangkok, Thailand (Mr Prapath Premmani, Secretary- General); ESCAP-REDP, Bangkok (Dr.F. Harahap, REDP, Senior Coordinator).

2. Nov.1-Nov.9: Small Hydel Board (SHDB), Kathmandu, Nepal (Mr. A.K.Shrestha, Project Director).

3. Nov.9-Nov.15: ESCAP-REDP, Bangkok (Dr F. Harahap).

4. Nov.15-Nov.20: Mini-Hydro Development Office, National Electrification Administration, Manila, Philippines (Ms. Z. Santos, Executive Director).

Summary and Conclusions

a) The three-person Mission received a warm reception from national focal points, UNDP offices and related organisations in the three

countries visited: Thailand, Nepal and Philippines. We wish to record our gratitude to all those who helped us during our visits,especially in arranging last-minute changes which proved necessary.

b) In each country, the major organisations involved in SHP were contacted and a greater understanding of their activities and needs was obtained. Similarly, the Mission was able to review the past few years' work in setting up the RN-SHP and to discuss future plans for greater involvement of focal points in the network's activities.

c) Each focal point expressed support for RN-SHP activities, and provided new research + development proposals for discussion at the TAG meeting in Dec.1984. They all supported the work of HRC as Secretariat, and noted that HRC had resources of manpower, buildings and equipment already available.

d) The idea of decentralization of RN-SHP activities was discussed and keenly welcomed by the focal points. In this way, HRC could concentrate on organization and co-ordination of activities.

e) The Mission was able to assess and compare the relative strengths of focal points in SHP technology. This would be useful when deciding upon the extent of decentralization of RN-SHP activities.

f) The newsletter " SHP NEWS " (1st issue) was welcomed by all, especially by those who were actually mentioned in it. Dr. Harahap also commented that both technical and policy issues should be covered, and that fine arts specialists could help in improving the appearance.

g) There were impressive plans for SHP development in the 3 countries but the degree of actual implementation varied according to financial resources available. However, common points were firstly problems of high unit installed cost per kW, especially for stations below 100 kW; secondly, encouragement was given to local manufacturers, consultants and contractors; thirdly each country had limited resources both in the public and private sector to carry out R + D work to improve the technical and economic level of SHP stations.

h) It is recommended that such Consultation Missions are continued in future, with participation from not only HRC staff but also relevant personnel from other Asia-Pacific countries, so as to continue this exchange of first-hand experience within the Network. In particular, India should be included in the next mission.

Background

Since its formal establishment in mid-1983, the RN-SHP has engaged in a number of research, training and information activities. Up to the present time, most of these activities have been organised by the Interim Secretariat located at HRC (Hangzhou Regional Centre), with backstopping by UNIDO and ESCAP-REDP.

As the range of activities widened, and the required degree of involvement of focal points in ESCAP member countries increased, so it became increasingly apparent that a Secretariat Consultation Mission would be of value to sound out opinions for the RN-SHP Work Programme, exchange views on technical matters of mutual interest and to establish personal contacts as a basis for strengthening ties and inter-linkages in the Network.

Thus, part of the REDP funding under phase II for RN-SHP activities has been allocated to this Mission. The original plan was to visit four countries, but the trip to India had to be cancelled at the last minute.

Objectives of the Mission

Since the formal start of RN-SHP activities in 1983, 10 focal points have been nominated. The objectives of this Mission were to strengthen ties within the Network by reviewing past activities and exchanging views on the 1985-1986 Work Programme with selected Focal Points. Also, site visits and exchange of views on aspects of SHP technology were part of the Terms of Reference, details of which are given in Appendix 1.

Thailand

1. Contact Persons

Mr. Nakagawa, Deputy Executive Secretary, ESCAP.
Mr. Wanasinghe, Chief, Technical Cooperation Division, ESCAP.
Dr. Harahap, Senior Cooordinator, REDP, ESCAP.
Dr. Fan, Chief, Natural Resources Division, ESCAP.

Dr. Koide, Coordinator, BSW Network, ESCAP.
Mr. Premmani, Secretary-General, NEA.
Mr. Singh, Director, Energy Policy & Planning Division, NEA.
Mr. Chartdanai, Energy Policy & Planning Division, NEA.
Mr. Adul, Engineer, NEA.*

2. Discussions with ESCAP

The Mission made a courtesy call on Mr Nakagawa, Deputy Executive Secretary, who noted that HRC was an active regional centre and that the Chinese government had given much support to ESCAP activities in general. In another brief meeting, Mr Wanasinghe, Chief, Technical Cooperation Division, expressed his firm belief that the Network approach was the best way for information dissemination and technology transfer.

In discussions with REDP Senior Co-ordinator, Dr F. Harahap and Dr L.Fan, Chief, Natural Resources Division, Mr Zhu reviewed HRC's activities since its establishment in November 1981. Some video films were shown introducing HRC and its research and training work. As regards the future work programme, Mr Zhu thanked REDP for their support under phase II for RN-SHP activities, now sub-contracted to UNIDO for implementation. The most immediate item was the first TAG (Technical Advisory Group) meeting scheduled for 11-13 Dec. 1984. Dr Harahap gave the Mission a copy of the 2nd REDP Steering Committee report, and hoped a similar report could be produced after the TAG meeting.

The Natural Resources Division was keen to co-operate in RN-SHP activities where appropriate and asked to be kept fully informed. Their "ESCAP Energy News", part of the Biogas, Solar and Wind Energy Network activities under its Co-ordinator, Dr S. Koide, could help publicise RN-SHP activities, and could exchange information with "SHP News". Views were exchanged on how to improve "SHP News", and how to further use graphic design experts.

Furthermore, Dr Fan gave the Mission the report of the High-level Consultative Meeting (Sep. 1984, Bangkok), listing priority items for funding. All six proposals submitted by HRC had been discussed, and further action on three was now being pursued.

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All parties concerned agreed that the question of RN-SHP and HRC's institutional management and legal status should be borne in mind and resolved step-by-step.

3. Discussions with NEA

Mr Zhu introduced HRC's work to NEA staff including Mr Prapath Premmani, Mr Mohar Singh, Mr Chartdanai, and Mr Adum (former HRC Training Workshop participant); he showed some video films, and invited comments on the proposed 1985-86 Work Programme.

Mr Premmani gave his support to the programme, and commented that as regards future Training Workshops, NEA would particularly welcome inclusion of appropriate feasibility studies for SHP; low cost civil engineering structural design, especially for headworks and headrace which could account for 80% of civil costs. He supported the idea of revolving training courses, and noted that NEA had a training school where they hold micro-hydro operators courses. They were working on improved designs of medium head Turgo and low head propellor turbines. NEA was willing to co-operate on the electronic load controller (ELC) co-operative reserch project, and also to contribute to "SHP News".

Mr Chartdanai then gave a brief introduction to SHP development in Thailand which had started up vigorously in the wake of the 1973 oil crisis, and was now progressing at a steady pace. In the current 5-year plan (1981-86), NEA plans to have 92% of the villages electrified, with 75 micro-hydro stations (less than 200kW) and 25 mini-hydro stations (201kW to 6MW). So far, 20 stations, total installed capacity 5MW had been commissioned. Local participation, in both civil construction and equipment manufacture was a new trend. Furthermore, NEA is doing development work on the ELC to use it as a speed sensor which then drives a DC motor to actuate the turbine guide vanes or nozzle. This novel approach had been successfully tested in the laboratory and could widen the application of ELC's. Their experience with locally assembled ELCs showed that they were cheaper than imported Chinese-made mechanical governors and about half the cost of imported ELCs.

Typical breakdown of costs for an SHP station in Thailand was:

civil works	40%
electromechanical equipment	25%

distribution	25%
administration	10%

4. Site visits

Mr Chartdanai accompanied the Mission on site visits to 4 stations near Chiang Mai (see Map 1):

a) 1250 kW station (Mae Sarieng) built to high technical specifications using imported equipment, and buried steel pipe, diameter 1.8m, for the 3.8km long headrace resulting in an investment cost of about US$4000/kW, which is high for Thailand.

b) Huai Mao station, 20kW, 80m head, under construction with local participation, serving 102 households (420 people).A low wooden dam was being constructed, and 30% of construction costs was being contributed by local labour and materials, The labour was valued at the going rate for unskilled labour which was about US$2 per man-day. End-uses for this village-level project included cooling water for mushroom plantations, coffee grinding, and bamboo splitting.

c) Mae Tong Long, 35kW, 90m head, was built with a locally-manufactured crossflow turbine and imported governor, all housed in a simple wooden powerhouse,(fig.3). The station served 156 households, and was used mainly to meet lighting needs. The unit installed cost was US$3300/kW.

d) Pang Pong, 12kW, 55m, using locally-assembled ELC which cost US$1150.This ELC had been made with core parts supplied by ITDG and had been running for 2 years.

The Mission was impressed by the move to involve local villagers, along the lines practised in China, to reduce the Government burden and transfer technology to rural people.

Nepal

1. Contact Persons

Mr. A.K.Shrestha, Project Director, SHDB.
Mr. P.M.Pradhan, Acting Superintending Engineer, SHDB.

Mr. R.B.Shrestha, Director, Central Regional Office, SHDB.
Mr. B.K.Pradhan, Executive Secretary, Water & Energy Commission,Nepal.
Mr. H.M.Shrestha, Chief Engineer, Dept. of Electricity, Ministry of Water Resources.
Mr. A. Delaporte, Asst. Resident Representative, UNDP Kathmandu.
Mr. A. Bachmann, UNICEF.
Mr. E.A.Fry, Training Adviser, Inst. of Engineering, ILO.
Mr. E. Kramer, Himal Hydro.
Dr. K.L.Shrestha, Executive Director, RECAST.
Mr. A. Arter, Technical Manager, BYS.
Mr. K. Denghal, Engineer, IDS.
Mr. N.L.Shrestha, Dean, Inst. of Engineering.
Mr. M.R. Tuladhar. Asst. Dean, Inst. of Engineering.
Dr. Aryal, Director, Western Regional Office, SHDB.*

2. Discussions with SHDB and other Government offices.

The Mission had several discussions with SHDB officials including Mr A.K.Shrestha(Project Director), Mr P.M.Pradhan (Actg Superintending Engineer) and Mr R.B.Shrestha (Director, Central Regional Office). The latter two are former HRC Training Workshop participants.

SHDB was set up in 1975 to exploit the huge small hydro potential in Nepal. However, progress was hampered by the lack of trained manpower and unfavourable geographical conditions which make access difficult. These factors lead to high investment costs of US$4000/kW and upwards. His Majesty's Government of Nepal considered SHP a priority area, and SHDB was seriously interested in participating in RN-SHP activities. At present, 9 stations of total installed capacity 1.7MW were in operation. In the 7th 5-year plan starting July 1985, SHDB would concentrate on stations in the mini range i.e. a few hundred kW and above, leaving the micro end (less than 100kW) to private entrepreneurs. The latter included the possibility of converting about 25,000 old water mill sites using multi-purpose power units for electricity and shaft power.

SHDB was keen for RN-SHP to include work on cost reduction, such as appropriate project selection methodology, rationalised design process, including computerization to cut down design time and optimize designs, improved hydrological estimation for ungauged rivers (a particularly

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acute problem for Nepal where not only are flow records scarce, but flow variations are extreme, say 1 to 3,000 between wet and dry season flows). Their aim was to reduce the unit installed cost from the current range of US$4000-7000/kW to a range of US$2000-3000/kW.

Mr A.K.Shrestha thought the revolving training courses a good idea, as also future consultancy visits either to assess Nepal's resources or using Nepali experts to visit other S.E.Asian countries. As regards the ELC project, however, there was no suitable site in Nepal for conducting field tests, since most stations had reservoirs.

The Mission also met Mr B.K.Pradhan, Executive Secretary of the Water and Energy Commission, who explained that only 126MW out of a theoretical potential of 83,000MW had been exploited so far. Another two stations totalling 98MW were under construction, but Nepal had no substantial home power market as yet, with 91% of energy demand being met by fuelwood and biomass. By 1990, 40 SHP stations would be in existence with total installed capacity of 13MW. Village participation in construction would be difficult in Nepal because of lack of local expertise and economic constraints on donating labour free of charge.

The Mission paid a courtesy call on Mr H.M.Shreshta, Chief Engineer, Dept of Electricity, Ministry of Water Resources. He repeated the need to reduce the cost of SHP and to train personnel in maintenance and operation of stations, and hoped the activities of RN-SHP would take this into account.

3. Discussions with other organisations

SHDB arranged several meetings with interested parties covering a wide range of organisations.

3.1. UNDP/UNICEF/ILO

The Mission met the UNDP Assistant Resident Representative, Mr A.Delaporte and briefed him on HRC's activities. He in turn arranged meetings with Mr A.Bachmann, UNICEF, with whom HRC had previously had correspondence, and Mr. E.A. Fry, ILO.

Mr Bachmann's main concern was at the micro scale, and he presented the Mission with booklets on multiple purpose power units. Furthermore,

he encouraged HRC to send "SHP News" to consultants and equipment manufacturers in Nepal.

Mr Fry, Training Adviser to the Institute of Engineering, Tribhuvan University, requested HRC to provide practical training in China for one or two Nepalis for a period of a few months. These people would then return to the University to train future SHP engineers and operators.

3.2. Himal Hydro

This is a local contractor formed by the Dept of Electricity and United Missions to Nepal. Mr Ed Kramer introduced their work, saying their main strength was in tunnelling. The main difficulties they faced were in hydrological design, design procedures for SHP and simplified construction methods. Methods adopted in China were discussed.

3.3. Research Centre for Applied Science + Technology (RECAST)

Dr K.L.Shreshta, Executive Director, explained how RECAST carried out R + D in fields relating to national development. They were concentrating on renewable energy sources, and in the field of micro hydro, they had worked on multi-purpose power units, 15-20kW turbine packages and turbine-pumps. They were keen to improve dissemination of SHP information, and welcomed the publication of "SHP News".

3.4. Balaju Yantra Sala (BYS)

Mr Arter, technical manager of this equipment manufacturing company set up by the Government and SATA (Swiss Agency for Technical Assistance), explained how BYS made only crossflow turbines up to 150kW and 100m head, with a guaranteed efficiency of 75%. He discussed problems of crossflow turbine design, operating problems at remote sites and the lack of reliable governors or load controllers. He also raised several topics that could form the basis of RN-SHP Co-operative research projects:

a) development of an improved water-actuated mechanical governor

b) prototype manufacture and testing of a high head, high efficiency crossflow turbine of up to 200kW

c) setting up of an independent turbine performance test facility in the Asia-Pacific region.

3.5 Integrated Development Systems (IDS)

This private consulting firm was established in 1979 and concentrated primarily on socio-economic development work. However, they had an interest in civil engineering design through their Mr K.Denghal and had previously carried out some work for SHDB on computer optimisation of SHP design. At present, each SHP station has to be individually designed, thus requiring a large team of engineers. Even if engineers were available, it is difficult to produce an optimum design because of the huge number of factors that have to be considered. IDS's proposal is to evaluate these factors by a computerized system which uses advanced dynamic optimization techniques. SHDB submitted a research proposal based on this work for further program development, documentation and printout of rationalised designs. The following modules are proposed, of which 16 have already been prepared:

1. Retaining walls
2. Slope stability
3. Earthwork quantity calculation
4. Hydraulic design of various canals
5. Structural design of intake structures
6. Structural design of saddle piers
7. Structural design of anchor blocks
8. Hydraulic design of intake structures
9. Hydraulic design of forebays
10. Structural design of forebays
11. Structural design of aqueducts
12. Hydraulic design of desilting basins
13. Structural design of desilting basins
14. Design of penstock pipes
15. Rating curves
16. Reservoirs
17. Different types of crossings
18. Power houses
19. Tailrace
20. Gravel trap
21. Lateral spillways
22. Study of construction materials
23. Analysis of rates for different mountainous regions

24. Hydrologic design

Mr Zhu said he would follow this matter up at the coming TAG meeting.

3.6 Institute of Engineering, Tribhuvan University

Mr. Zhu gave a presentation on SHP in China, and supplemented this with video tapes. The Mission was then shown round the Institute and its laboratories.

4. Site visits

The Mission went to Pokhara, a 5-hour drive from Kathmandu,see Map 2, and was hosted there by Dr Aryal, head of the SHDB Western Regional office and also former HRC Training Workshop participant.

Some time was spent at three sites:

Pokhara Water Conservancy, Irrigation and Power Project

This project was designed and built by the China International Water and Electric Corp, (formerly HECC) and included a 3X500kW powerhouse which utilised the 23m head drop on an irrigation canal. The headworks consisted of a diversion weir on the river Sedi, sluice gates, intake gates and desilting basin. The main canal capacity was 11m³/s, serving an area of 1030 hectares, and 8.9m³/s was available for power generation. The length of the whole canal system was 40km. The project was administered by the Dept of Irrigation. Construction started in Nov.1981 and the turbines were now undergoing commissioning trials including parallel operation.

Syangja SHP station

This 80kW station was designed, constructed, equipped and operated by SHDB in conjunction with local organisations,fig.1. BYS crossflow turbines were installed, together with their water-actuated governor,fig.2. The working pressure of this specially designed governor is supplied by the water head on the turbines (about 10m head is required). Regulation performance is only to within plus or minus 10%, response is slow and tuning of the governor is still rather difficult. Torque capacity is 10

to 20 kg-m. Nevertheless, the governor is simple and tough, with a quoted price of US$3000, twice the cost of the turbine. Further R&D on this device is considered to be of value to the Asia-Pacific region. The civil works included a 1km long headrace and daily regulation reservoir. Construction took 2 years, and so far 124 households (38kW load) have been connected to the power supply. Installed cost per kW was quoted as about $4000. There was local participation in construction but on a paid basis. 17 staff, including administration, operated the plant, with 4 persons per shift.

A BYS engineer was on site at the time to replace the crossflow turbine runner. Subsequent analysis in the lab showed that the blades had already undergone 24 million load changes before breaking. This greatly exceeded the limit of 6 million load changes to be expected if failure was due to fatigue stress. Thus,deficiency in material strength was not a cause of failure, and it was hypothesised that excessive impulsive forces may have been experienced due to flat stones entering the trashrack, especially as intake velocities were high when forebay levels were run low.This shows the importance of using a fine mesh on the trashrack when crossflow turbines are installed.

The engineer noted the problems of access to the site. Syangja was relatively favourable in this respect, with access by 1/2hr jeep ride on a bumpy dirt track followed by 15mins on foot, including crossing a simple hanging bridge over the river. Transport costs in extreme cases could account for up to 75% of a project. The cost of a bag of cement could be double or triple that at Kathmandu by the time it reached the site. Also, delays in maintenance could even force a station to shutdown for several months.

Phewa Lake SHP station

This was designed by Indian engineers and consists of 4X250kW turbines using 90m head. Water supply was from Phewa Lake which had been dammed primarily for irrigation purposes. Funding for the dam construction had come from UNCDF.

Philippines

1. Contact Persons

Ms. Z. Santos, Executive Director, Mini-Hydro Development Office, NEA.
Mr. E. Piamonto, Mini-Hydro Development Office, NEA.
Ms. R. Royeca, Mini-Hydro Development Office, NEA.
Mr. C. Ilustre, Group President, Machinery Systems Group, AG&P.
Mr. R. Villeneuve, Vice President, Machinery Systems Group,AG&P.
Mr. R. Limson, Manager Mini-Hydro & Electrical Section, Machinery Systems Group, AG&P.
Ms. E. Graham, Training & Information Coordinator, NRECA.*

2. Discussions with Mini- Hydro Development Office

The Mission had several discussions with Ms.Z.Santos, Executive Director and her colleagues, all conducted in a friendly atmosphere. As at previous meetings with SHP Focal Points, Mr Zhu outlined HRC and RN-SHP activities since 1981, exhanged technical literature and handed over a videotape containing 7 video films so that NEA could make a copy.

The SHP programme in the Philippines had an ambitious target of 300MW to be installed by 1991. 13 plants had so far been commissioned with total installed capacity of 12MW, and feasibility studies for 95 sites had been completed. However, because of the economic situation, a slowdown in the programme was being experienced. Turbines ordered from China under a loan agreement were in store, and they were seeking ways of converting the remainder of the loan to help in station construction.

On future activities, Ms. Santos noted that they were interested in capacities over 100kW, so that the proposed Electronic Load Controller co-operative project would not be suitable for NEA's needs. On video filming, they were keen to collaborate, and indeed had their own expertise in mass communications which could be made available. As regards training workshops, she emphasised that participants for these should come from countries at the same or similar stages of development. ASEAN countries had identified civil works as the main topic for their next training course.

Ms. Santos strongly supported the idea of decentralization of RN-SHP activities, and was keen to work hand in hand with HRC on this.

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As regards R + D work, they presented an outline of their needs and priorities. The Mini-hydro office had only limited experience but could collaborate in data collection for example. They considered geological investigation to be an important area, especially for design of headrace and penstock to be safe against erosion and landslides.

3. Discussions with other SHP related organisations

3.1. AG&P (Atlantic Gulf and Pacific), Machinery Systems Group.

The Mission received a hospitable reception from AG&P, visiting both their corporate headquarters and the Honiron Division which manufactures turbines under licence from CMEC (China Machinery and Equipment Corporation). So far, 9 turbines have been manufactured for 4 Philippine SHP stations and they are exploring markets in other ASEAN countries.

AG&P commented that they had participated in UNDP-sponsored training courses. They would convey their comments on RN-SHP activities to Ms Santos after reviewing the material presented by Mr Zhu.

3.2. Philec (Philippine Electric)

This company manufactures a wide range of electrical equipment for power generation, and also has a licence agreement with Barber (Canada) for turbines.

They also acted as contractors on the Batchelor SHP station, and Mr Zhu requested details of the fibreglass pipes used for the headrace at Batchelor.

3.3. NRECA (National Rural Electric Co-operatives Association),USA

The Mission met Ms E.Graham, Training & Information Coordinator, NRECA for a brief discussion on future co-operation in the field of training. NRECA had just completed their first course on SHP hydrology for the ASEAN region. They preferred to work on a sub-regional basis, with much emphasis on systematic development of course materials by lecturers who could meet several times during the course of preparing lecture materials so as to ensure continuity and to avoid duplication. NRECA were currently seeking funds for development of course materials for the second ASEAN training course.

Discussion then followed on how NRECA and RN-SHP resources could be combined to hold joint training courses for the Asia-Pacific region and elsewhere.

4. Site Visit

The Mini-Hydro Office and AG&P accompanied the Mission on a visit to Batchelor SHP station, fig.3, at Natividad, Pangasinan (see Map 3), where PANELCO (Pangasinan Electric Co-operative) III is located. Installed capacity is 3x250kW with turbine-generators imported from China, supplying 16,000 people in 3,000 households. In the Philippines, the NEA builds the SHP station, after which operation and management is handed over to the local co-operative made up of members from the consumers. Only 2 operators plus 1 co-ordinator were needed per shift.

The station was not operating since a recent typhoon had caused a landslide which had damaged a section of the exposed fibre glass headrace. Thus, supply was met by the grid, costing the co.operative 1.04 pesos/kWh, compared with their own SHP generating cost of 0.65 pesos/kWh.

The installed cost of this station was about $7000/kW.

Appendix 1

REGIONAL NETWORK FOR SMALL HYDROPOWER (RN-SHP)

"CONSULTATION MISSION"

T E R M S OF R E F E R E N C E

* * * * * *

I. Consultation with SHP focal points on the strengthening of the Networking mechanism:

a. Review activities of Phase I (1982-1983);

b. Present and exchange views on the Work Programme for Phase II (1984-1986);

(These two items will be supplemented by technical presentations, video films and technical literature as relevant)

c. Discuss actual needs and priorities identified by the national SHP focal points, towards elaborating practical programmes for the future;

d. Discuss increased involvement of national SHP focal points in decentralized activities in the future, e.g. undertaking joint R+D projects, organizing joint training workshops as well as the distribution of specific tasks;

e. Discuss topics for future collaborative research projects;

f. Establish regular channels for information exchange for SHP rosters, newsletters, etc.

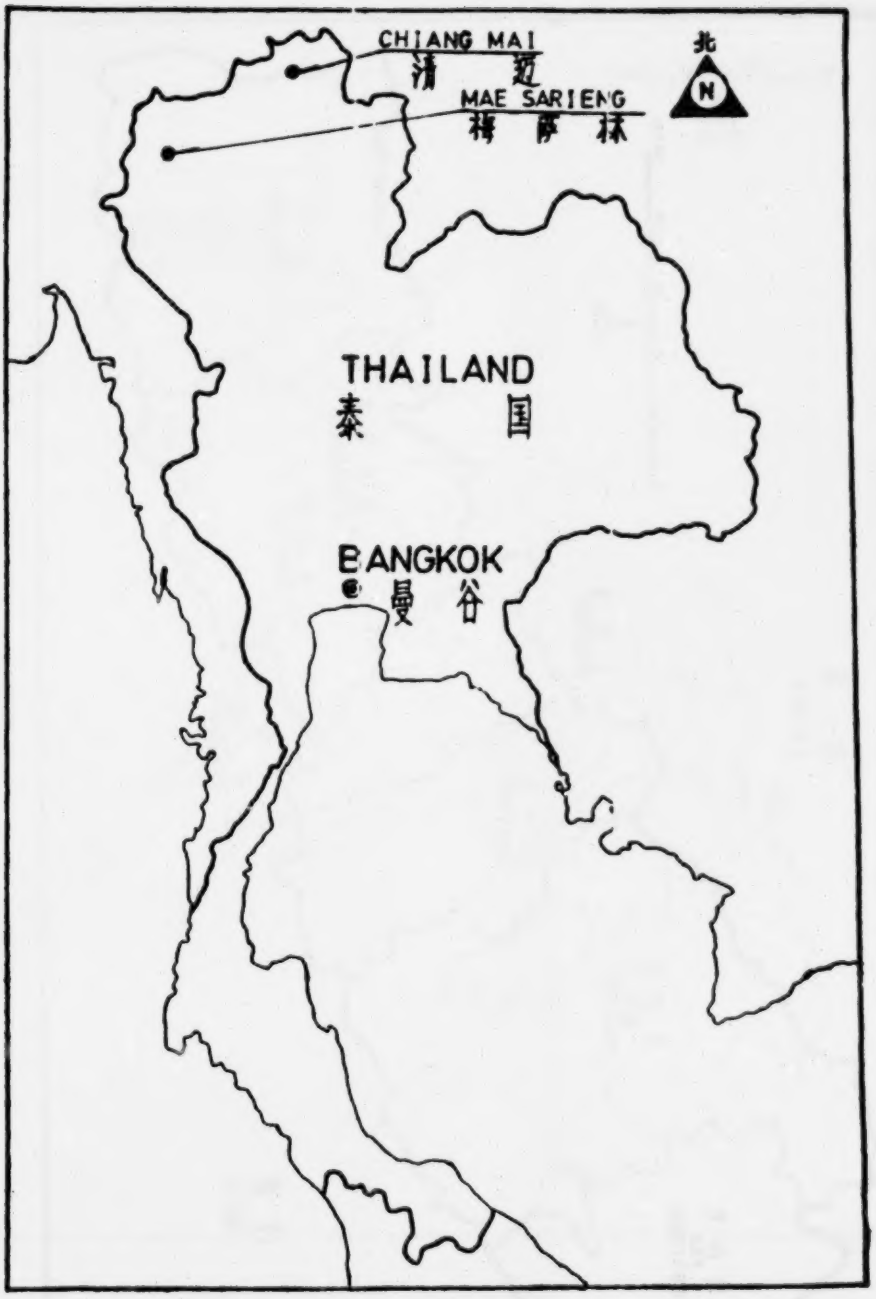
II. Through arrangement with the national SHP focal points, visits to relevant organizations and SHP sites:

a. Establish contacts with those organizations which have invited the Hangzhou Regional Centre (HRC) for discussions;

b. Visit other institutes or centres active in technical areas relevant to SHP as recommended by the SHP focal points;

c. Visits to selected small/mini/micro hydro stations, organized by the national SHP focal points;

d. Visits to selected SHP equipment manufacturers to discuss possible regional co-operation; etc.



Map 1 THAILAND
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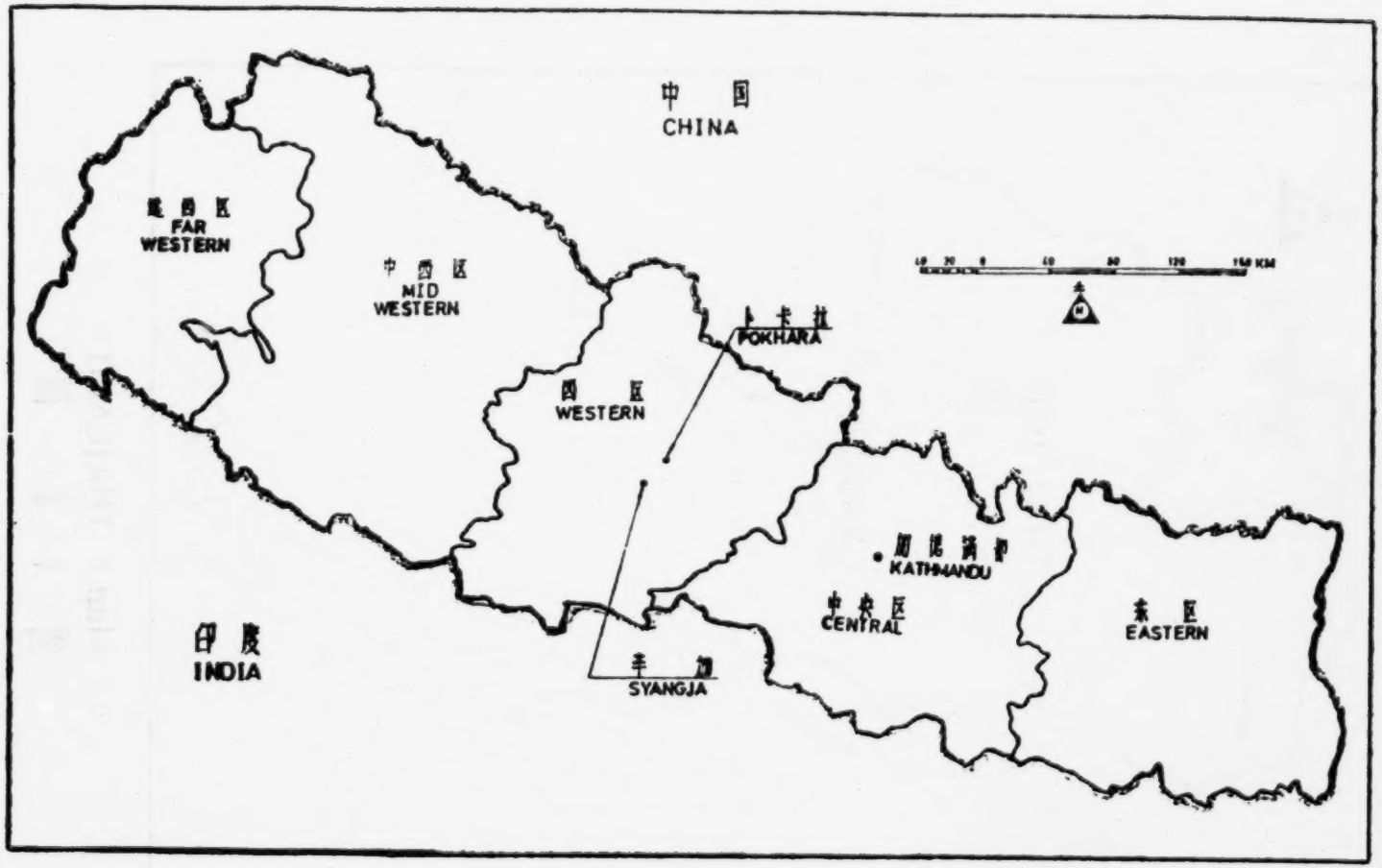
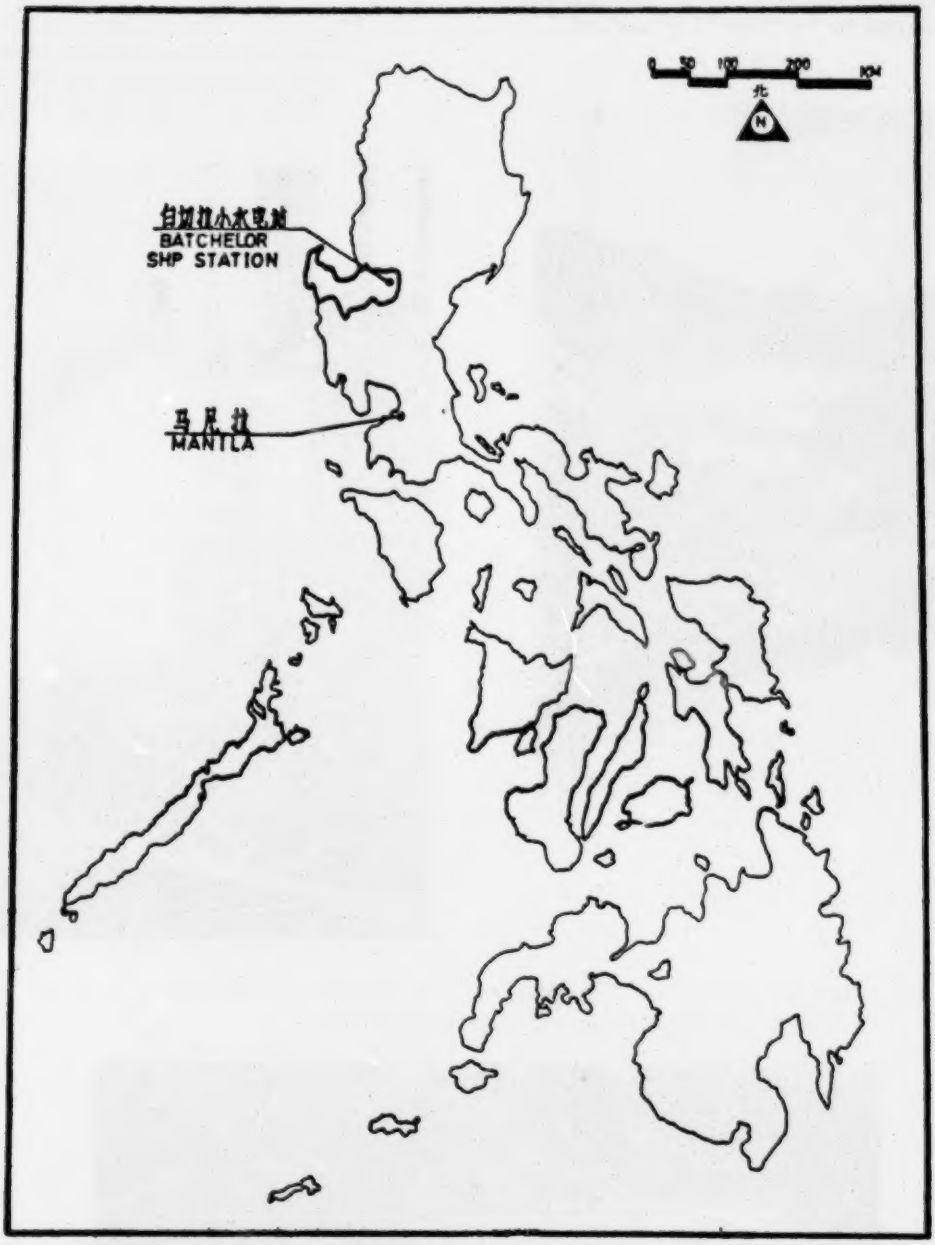


Map 2 NEPAL

图 2 尼泊尔



Map 3 PHILIPPINES
图 3 菲 律 宾

Figure 1: View of Syangja SHP station (80kW), Nepal, showing rugged terrain and difficulties in accessibility. (This site is relatively favourable by Nepali standards).

Figure 2: Novel water-actuated mechanical governor, designed and manufactured by BYS Ltd. Nepal and installed at Syangja.

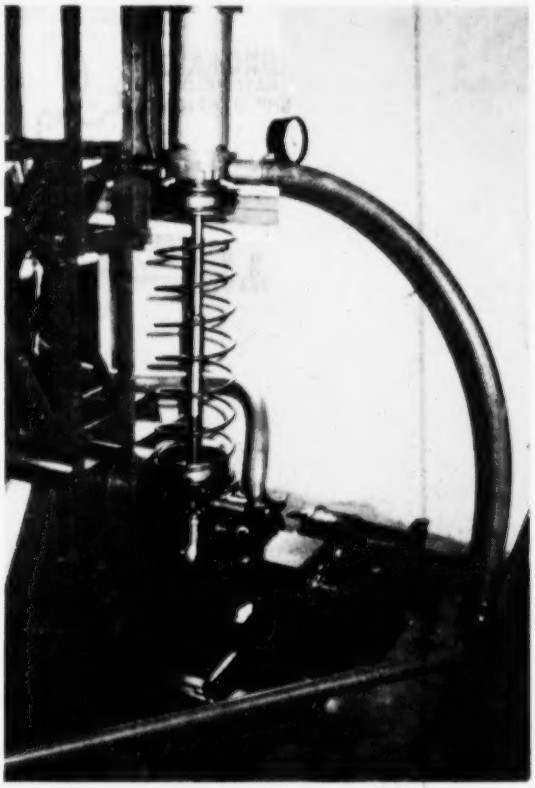


Figure 3: View of Batchelor SHP station, Philippines (750 kw) equipped with Chinese turbine-generators.

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ESCAP Regional Energy Development Programme (REDP)
Regional Network for Small Hydropower (RN-SHP)

Technical Advisory Group (TAG)
First Meeting

Hangzhou, China, 11 - 13 December 1984

POTENTIAL CO-OPERATIVE RESEARCH AND DEVELOPMENT PROJECTS*

Agenda item 5(b)

Prepared by

Interim Co-ordinator of the
Regional Network for Small Hydropower

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TABLE OF CONTENTS

		Page
A.	Design Manual	1
B.	Guidelines/Criteria in the Efficient and Economical Design of the following structures and areas	2
C.	Optimum design systems for small hydro-power project - a research project proposal - summary	4
D.	Mechanical water-actuated governor	7
E.	Water supply line	12

A. Design Manual*

A textbook suitable for experienced graduate engineers without specialist knowledge of hydro power is suggested.

It would cover all aspects of design including:

- Pre-Feasibility Studies
- Feasibility Studies
- Hydrology and Water Management
- Scheme Optimisation
- Dams and Weirs
- Intakes
- Gates + Stoplogs
- Canals
- Penstocks
- Surge Chambers
- Surge Analysis
- Water Hammer
- Turbines
- Governors
- Relief Valve
- Generators
- Auxiliary Systems
- Control + Supervisory Systems
- Protection and Switchgear
- Powerhouse Layout + Design
- Transformers
- Switchyards
- Transmission
- Operation

The manual would include sample computer programs (based on programs already developed) covering:

- quick estimates of cost (for pre-feasibility studies)
- simulation of scheme operation
- intake design
- gate design
- penstock design
- water hammer
- surge chamber design
- head losses
- turbine costs, characteristics and dimensions
- generator costs, characteristics and dimensions

Model specifications and drawings covering all aspects of the design process would also be provided.

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* Outline prepared by Leyland, Watson and Noble, Auckland, New Zealand. (Mention of firm names and commercial products does not imply the endorsement of the United Nations).

B. Guidelines/Criteria in the Efficient and Economical Design of the following structures and areas*:

I. Geology

- structural design and requirement to areas prone to landslide and tremors/ erosion
- sub-surface exploration - Dam location, headrace, penstock etc.

II. Hydrology

- application of computers in hydrological data gathering
- assessment of hydrological data requirements
- probability/correlation method
- hydrological investigations and investigations related to hydraulic structure and hydraulics.

III. Diversion Dam Arrangement

- criteria for Run off River
  arrangement, daily regulation storage
- choice of type of dam or weirs
- criteria for using gates at specific type of dam
- design of dam/weir for peaking
  improvement of availability factor
- Dam stability and Seepage

IV. Intake Gates/Scour Gate

- Type/Design of gate for efficient and easy operation (Manual)
- Electronically operated Gate controlled at the Power Plant
- Desilting arrangement and sediment transport
- Corrosion protection

V. Headrace/Water Conveying System

- Criteria for open canal system, the use of concrete canal, fiberglass or steel pipe
- Criteria for tunnelling

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* Prepared by NEA (National Electrification Administration), Manila, Philippines.

- Design of the canal to minimize losses, and seepage and improve stability
- economic route of conveying system
- Erosion protection and drainage design

VI. Forebay/Surge Tank

- Criteria for the selection of forebay or SurgeTank
- Materials to be used in surge tank
  Fiberglass - steel
- Desilting arrangement at Forebay and Volume of water to be stored

VII. Penstock

a. Materials to be used

b. Drainage design of Penstock

c. Erosion protection/Soil Stability

d. Effective and Efficient Penstock Transport

e. Use of Expansion joints

f. Corrosion protection

g. Penstock design with provision for flushing

h. Penstock testing

- X - ray test - welding
- Hydrostatic test
- Ultrasonic test

VIII. Electro Mechanical Equipment

- Type of generators for multiple installation of units in an area
- Type of turbine for a given design head

IX. PowerHouse

- Standardization of powerhouse design
- Development of indigenous materials available in the locality.

C. Optimum design systems for small hydro-power Project: A research project proposal - Summary*

Background

Small hydro-power projects constitute an important part of Nepal's regional and local infrastructural development projects. IDS proposes to develop, for the use of Small Hydel Development Board (SHDB) and other potential users in His Majesty's Government, package of rational design standards for such projects to improve technical and economic efficiency in design and construction. IDS has already developed 15 different computer programmes for SHDB. This proposal seeks to continue the research work to its full completion.

At the moment, each mini hydro plant must be individually designed as each site is unique and has its own peculiar problems. Each design requires a large team consisting of a geologist, a hydrologist, a soil scientist, a mechanical engineer, an electrical engineer as well as a civil engineer. This has proved a handicap because there are few engineers with experience in this field. Even if engineers and specialists were available, their efficiency is constrained because there are no good reference books. Even a team of experienced engineers cannot satisfactorily carry out the task of rational site selection with optimum design of various structures in the absence of design standardization systems. This is possible only when thousands of factors relevant for designing various parts of the scheme are taken into account simultaneously to produce an optimum design. The innumerable factors can be properly evaluated only through a computerized system which utilizes advanced dynamic theories of optimization.

Justification

In the absence of optimum standards, the design system, as present, is influenced by subjective factors. The quality and cost of design as well as that of construction varies from person to person or from one designer to another. The cost per kilowatt of small hydro-power has varied widely from Rs. 25,000 to Rs. 130,000 in Nepal as reported in a study made by the Water and Energy Commission. The present lack of national standards and

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* Submitted by the Small Hydel Development Board of Nepal (SHDB/Nepal).

norms for design also critically affects site selection and inhibits quality control in design and construction. The development of a design standardization system is therefore necessary to effect cost uniformity, cost reduction, savings in skilled manpower, rational site selection and to better enforce quality control.

Objective and scope of work

The primary objective of the proposed research is to improve the technical and economic efficiency of small hydro-power development projects in Nepal by developing a computer based design system. The initial phase of the research work will build upon the separate computer programmes already prepared by IDS for SHDB to develop an integrated package of optimal design programmes. After this computerized system is set up, the following documentation will be prepared.

(i) an Operational Guide for the use of SHDB and other concerned HMG personnel engaged in the design of small hydro-power projects. It will describe in detail how to operate and use the computerized design systems.

(ii) a Design Manual which will provide all information on the theoretical aspects of optimizing design systems for small hydro-power projects and the empirical formula utilizing the hydrological and other relevant data of Nepal on a region-wise basis.

(iii) a Manual of Design Rationalization which will include thousands of typical, rational design standards, ready for instant use, covering all types of hydrological and geological factors involved in any zone of Nepal. With this manual, it will not be necessary to have access to a computer or to the package of computer programmes to utilize the optimal results of the design systems.

Manpower and staffing

The research study will require a rather big team of skilled personnel including hydro-power experts (34 man-months), geologists (12 m/m), hydrologists (14 m/m), soil scientists (16 m/m), economists (12 m/m), and electro-mechanical experts (6 m/m). The Senior Systems Analyst (40 m/m) at IDS will be the key person guiding and coordinating the research. The research work itself will be carried out by IDS experts and consultants. It is also proposed that His Majesty's Government make arrangement for deputation of appropriate senior experts (on a part-time basis) to IDS to ensure full consideration of the Government's view and requirements during the research work. This arrangement will also facilitate transfer of design skills and tools in this field to the Government.

Budget

The estimated total budget for this research project is Rs.17.78 lakhs for the three year period.

Project benefits

The most immediate benefit of this research will be the savings in the cost of design and construction of small hydro-power projects. It will provide considerable savings of scarce technical manpower and project time; and also improve technical efficiency by facilitating rational site selection and quality control. Substantial indirect benefits will also be obtained. The computerized designs will be based on the maximum use of locally available building materials and labour intensive methods. There will also be some spillover benefits. It is estimated that about 40% of the computer programmes can be directly used by the Department of Electricity for the design of medium and large-scale hydro-power projects.

The savings in the cost of construction alone will far exceed the initial investment in this project. Under the least optimistic outcome of a 15% reduction in construction costs, the net benefits of the project will be Rs. 2.8 crores within five years even if only two small hydro-power projects are designed and constructed every year.

D. Mechanical water-actuated governor*

Speed Governor

To be able to keep the turbine speed within tolerable limits, independent on the (varying) load connected, a governing system is required.

The method generally applied is flow-control, where the volume of water (discharge) through the turbine is adjusted to match the turbine power with the actual load. This, in turn, guarantees that voltage and frequency of the electric supply remains within a specified range.

Such type of speed-control is provided by SHDB's mechanical/ hydraulic governor which uses water as a working medium. The working pressure (used to open the turbine) is supplied by the head of the installation, whereas a spring serves to close the turbine-valve.

Main Components

The device consists of the following main parts:

- flyball assembly (centrifugal pendulum)
- throttle / control valve system
- servo-cylinder / closing spring
- water supply line (pipe, tank, filters)

A schematical overview is given in fig. 1. (page 9)

Brief Description of Main Components

a) Flyball Assembly

The centrifugal pendulum is directly mounted on the turbine shaft and serves as a tachometer. The flyball mass will shift a pushrod against a spring depending on turbine speed. Thus, for each turbine speed (within $\pm$ 10% of rated speed) there is a respective position of the flyball pushrod.

This position may be altered by varying the pretension of the flyball assembly spring. This is used for the adjustment of the nominal speed when the governor is tuned initially.

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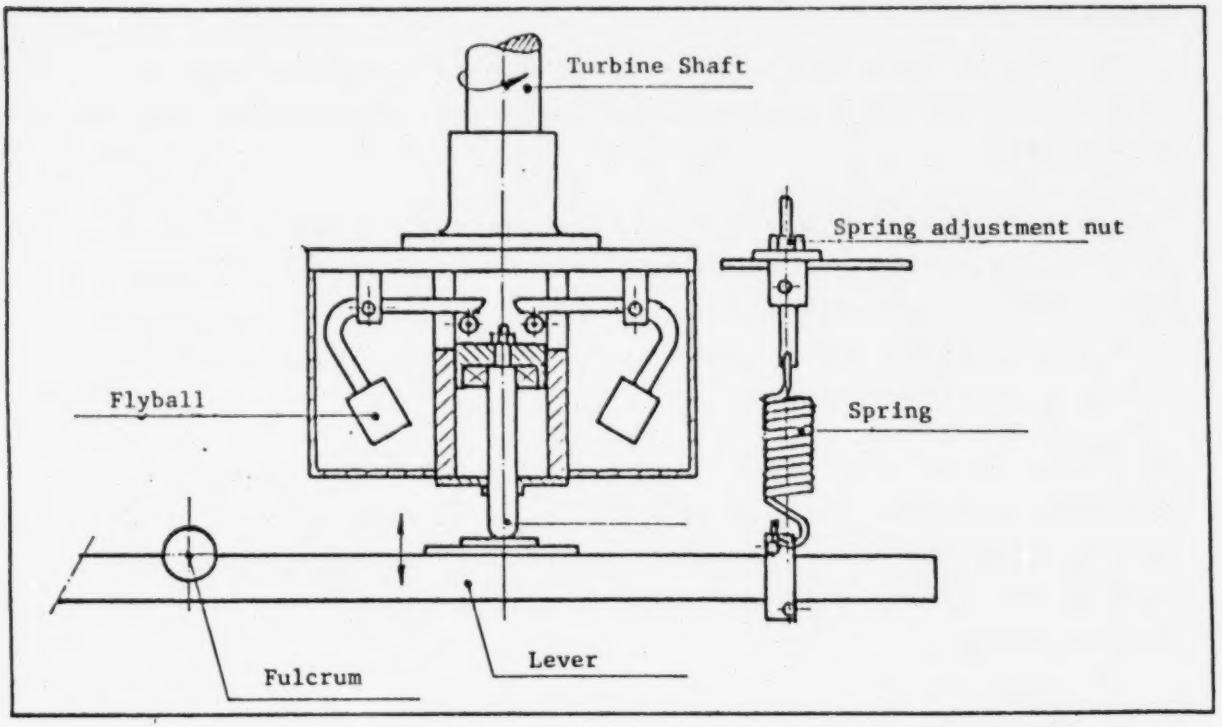
* Prepared by BYS, Nepal.

Figure 1: Schematic of Flyball Assembly

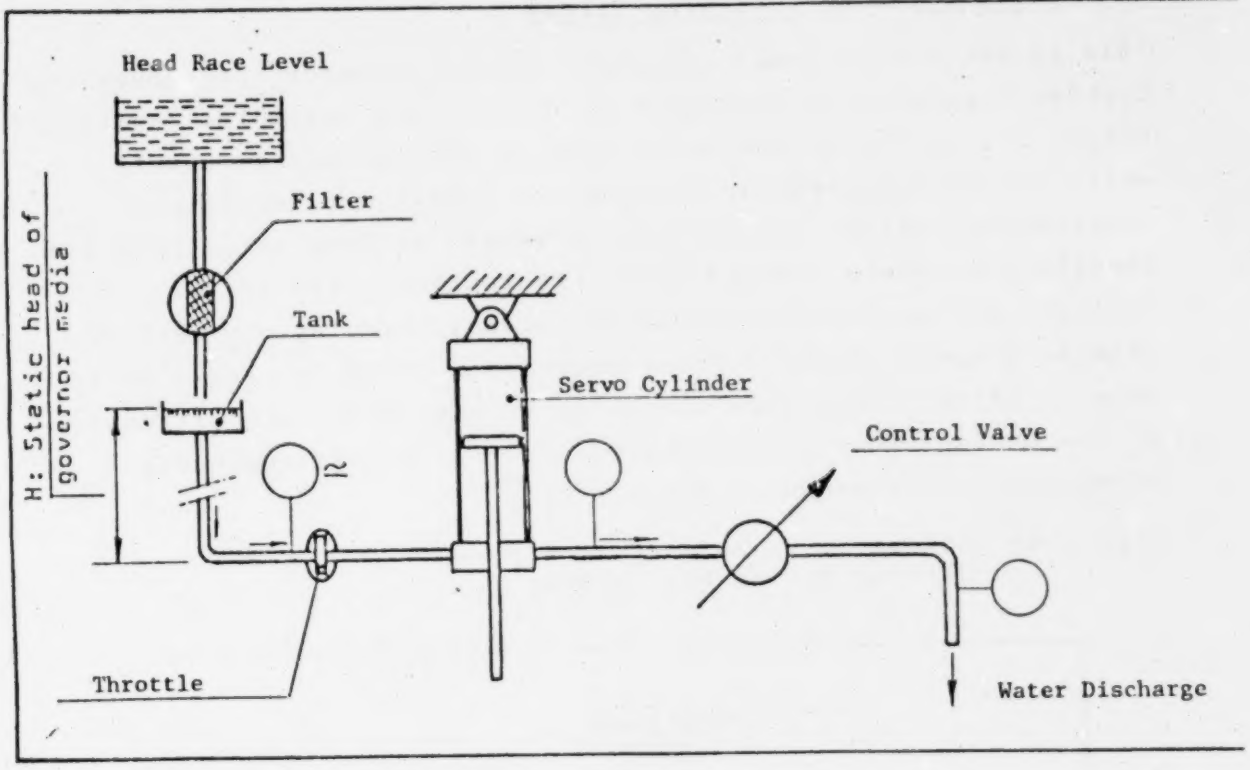


b) Throttle / Control Valve System

The principal function of these components is to vary the water pressure in the servo-cylinder as required by varying load condition of the turbine. Water, under the static head of the installation, is brought in a separate pipe to the governor; it passes first through the throttle and is discharged into the turbine pit through the control-valve. Between throttle and control-valve, the hydraulic cylinder is connected to the system as indicated in fig. 2. (page 10).

The pressure P_1 may be varied by varying the discharge area A_1 in the control-valve. The shape of the control-valve piston is designed such that the characteristic of P_1/P_o over the stroke of the control-valve is linear. If the control-valve piston is connected via a lever-linkage to the flyball/pushrod it is possible to get a speed and load defined pressure P_1, acting on the servo-cylinder.

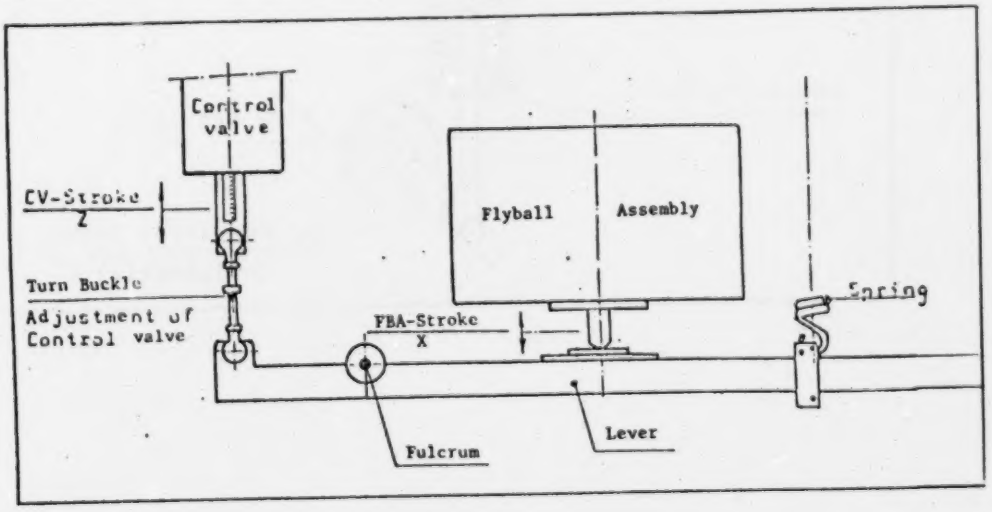
Figure 2: Schematic of Throttle / Control-Valve System



c) Lever-Linkage

The lever, as indicated in fig.3, serves to transmit the reaction of the flyball assembly to the control-valve piston when the turbine speed changes. The flyball spring is attached to the same lever, to counteract the flyball effect. The arrangement shown in fig.3 serves to adjust the position of the control-valve piston in relation to the flyball pushrod position. The adjustment is necessary for the governor tuning.

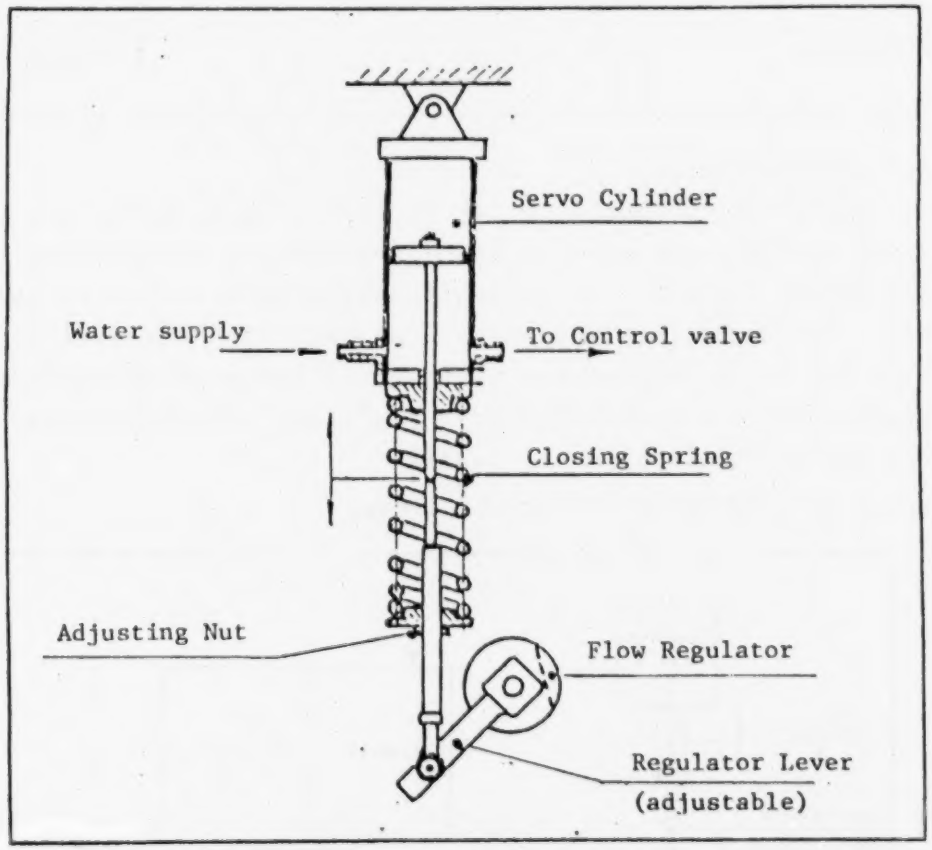
Figure 3: Schematic of Lever Linkage



d) Servo-Cylinder / Closing-Spring

This is the actual power component of the governor that moves the turbine-regulator as commanded by the flyball assembly. Hydraulic forces act in the direction of opening the turbine gate only, while forces required for closing are supplied by a helical compression spring. In the static state, as long as no load and therefore no speed changes occur, hydraulic forces in the cylinder and spring forces are in balance, keeping the turbine gate in a speed (load) defined position. It is necessary to be able to adjust the stroke of the servo piston and the pretension of the spring, when tuning the governor. The corresponding arrangements are shown in fig.4.

Figure 4: Schematic of Servo-Cylinder / Closing Spring Arrangement



e) Water Supply Line

The water supply line consists of four elements:

- supply pipe (2 inch GI pipe)
- filter
- supply tank
- several valves (standard, 2 inch)

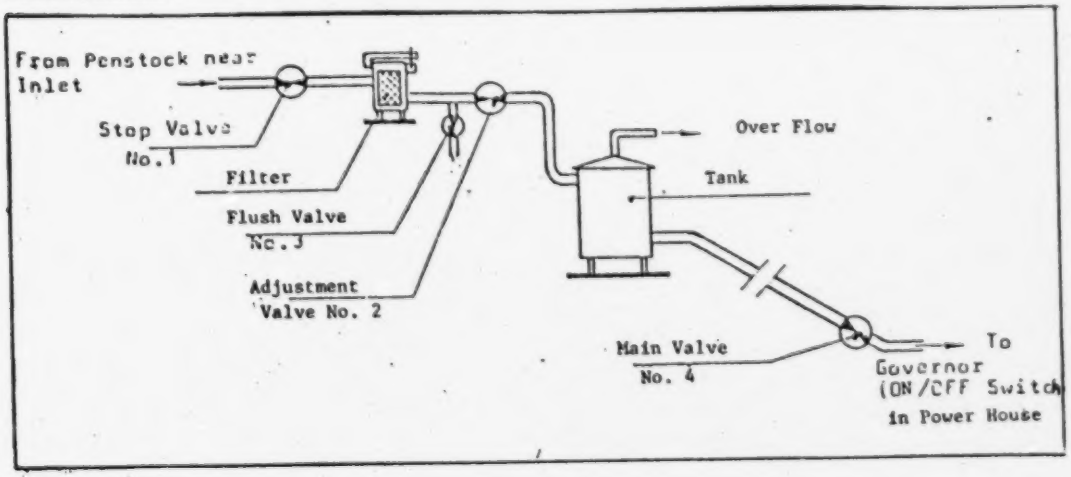
The water is taken from the penstock near the inlet. To avoid abrasing or jamming of the control valve, it is absolutely necessary to filter the water that is used in the governor. A simple basket strainer type of filter serves for that purpose, the basket consisting of very finemeshed nylon - gauze. Filter pressure required is between 2 and 3 metres.

The filtered water is collected in a tank of approx. 100 lt volume from where a 2 inch GI pipe brings the water to the governor. The tank provides an almost constant level and hence static pressure to the governor, which makes the governing characteristic independent of the water lever in the forebay and prevents shock waves that may occur in the penstock from adversely affecting the governor's performance.

Several valves are incorporated, having the following purposes:

- No.1, Stop Valve: to clean the filter, and
- No.2, Flush Valve: flush the line
- No.3, Adjustment Valve: to adjust the discharge so that a small over flow results (and to clean/flush the filter)
- No.4, Main Valve: to start and stop the turbine (only valve to be operated to run the plant)

Figure 5: Schematic of Governor Supply Line



E. High head crossflow turbine (BYS, Nepal)

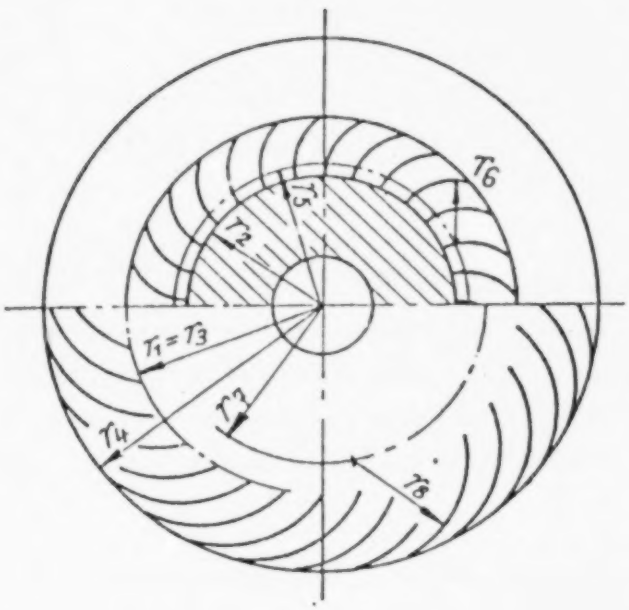


Fig. 1

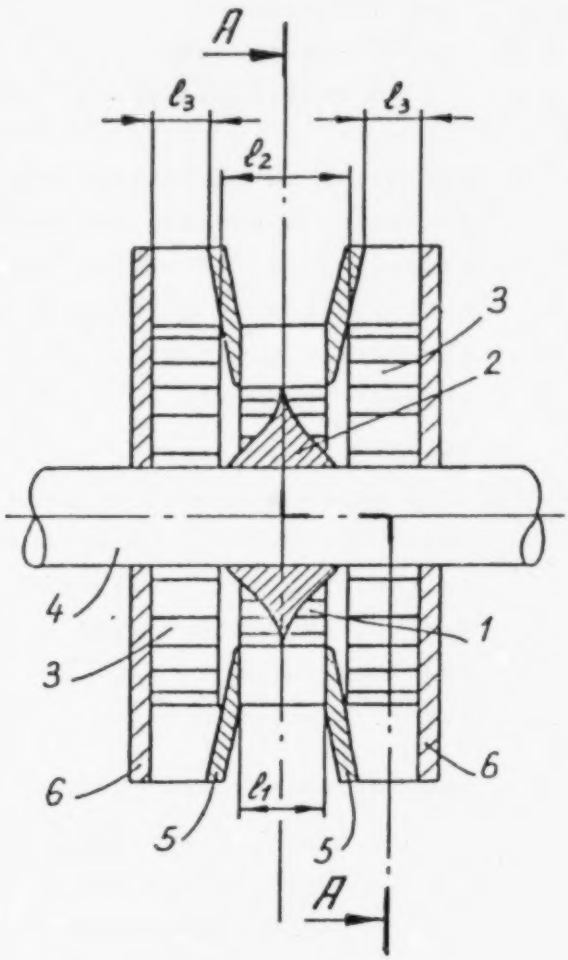


Fig. 2

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ESCAP Regional Energy Development Programme (REDP)
Regional Network for Small Hydropower (RN-SHP)

Technical Advisory Group (TAG)
First Meeting

Hangzhou, China, 11 - 13 December 1984

COUNTRY PAPER: CHINA*

Prepared by

Hangzhcu Regional Centre
for Small Hydropower

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V.85-21978

I. Priority Subjects for Workshops and Training Courses

Feasibility study

In this area, China has developed her own methods suited to the particular conditions in China. However, we are keen to learn from the experiences of other countries, and can help in organizing such a workshop or training courses.

II. Joint/Co-operative Research Projects

1. Electronic Load Controller

China has already completed a first stage research project on the testing and trial operation of an ELC in conjunction with the Intermediate Technology Development Group (ITDG). The results of this showed that two major problem areas are "how to reduce the costs" and "how to more effectively utilize the ballast load".

China is therefore embarking on the second stage involving the local assembly of 60kW ELC kits supplied by ITDG, and with the testings to be carried out in China and two other Asia-Pacific countries.

The results of this can then be disseminated throughout the RN-SHP to promote the wider use of ELCs.

2. Remote control and automation of SHP stations

China is working on telemetry in cascade stations in Panxi River and commissioning of the system is expected during the first half of 1985. The experience obtained from this project could be disseminated through the publication of research projects and direct site visits.

3. China is willing to organize a training course, for example on "low-cost civil engineering design" in 1986, with the preparation of teaching materials to be done with lecturing in conjunction with other experts from the Asia-Pacific region.

The inauguration of the Phase-II HRC building is planned for second half of 1986, and China is willing to host a "High-level Policy-Makers Symposium" to coincide with the opening ceremony.

China supports the work of the RN-SHP Secretariat in the field of information; China is actively compiling data on her own SHP stations and experts. Furthermore, China can participate in consultation teams where required.

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ESCAP Regional Energy Development Programme (REDP)
Regional Network for Small Hydropower (RN-SHP)

Technical Advisory Group (TAG)
First Meeting

Hangzhou, China, 11 - 13 December 1984

COUNTRY PAPER: MALAYSIA*

Prepared by

Hoesni Nasaruddin**

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** Mini Hydro Advisor, National Electricity Board, Malaysia.

V.85-21979

Recommendation on Priority Subjects for future RN-SHP Expert Group Meeting/Workshop

In the development of small/mini Hydro Power for a developing country in particular, the main aspect that should be considered would be whether the country is willing to develop the technology in line with the country's energy requirements, as well as, its capability in adapting foreign technologies to suit its priorities. Otherwise the venture can result in very expensive systems and may be in the end, be a failure, putting the country into debts unforeseen in the first instance. As such, there are several areas which should be considered after small/mini hydro is adopted by a country. Mini hydro development and technology can only be acquired by experience. From this statement, pilot and trial projects are necessary to gauge the ability of available manpower resources of the country, in handling such projects especially if large scale implementation is desired. In Peninsular Malaysia trial ad pilot schemes have presented new outlook into the issue. The areas that need to be studied in detail are the following:-

a) Current Civil designs in areas having high rainfall and high incidence of land slides

In Peninsular Malaysia, in particular, the tropical rain ,especially, in the monsoon season spans many months, can result in the earth in hillside areas to be water logged. Landslides are frequent and these can have disastrous effect on the total Mini Hydro Power Station system. Landslides normally occur at strategic positions e.g. cutting roads leading to Power Stations, landslides at pipelines anchor blocks, landslides at pole or tower position of transmission lines, landslides remote but at a higher level than the Power Stations and pipelines causing large rocks rolling down and damaging some parts of the system etc. The study in this area can mean:-

i) Changes in designing of anchor blocks for pipelines e.g. having deep rooted pole structures rather than flat boxes.

ii) Ensuring proper anchoring of Mini Hydro Power system i.e. the pipelines and the Power Station anchored to solid immovable rock structures if available.

iii) The building of specially designed non-metallised roads at specific locations with proper drainage.

iv) Studying the landslide phenomena and its reduction; say the planting of deep rooted trees at strategic positions.

The overall effect of this would mean that in putting up a Mini Hydro Station a bird's eye view of the terrain forest and

fauna and geology have to be looked into from the mentioned problem.

b) Hydrology of tropical forest areas and the factors affecting these due to deforestation and the recovery of the total system thereafter.

Where logging activities take place, hydrology in tropical forest alters tremendously. Recovery of the affected area takes some time but due to its inherent nature, recovery can be considered rapid. The change in hydrology can be seen due to the initial clearing of the area and the subsequent growth of small plants. The total picture of the situation means on the onset of logging activity, large amount of silt, branches logs and leaves are brought down by the river affecting the Mini Hydro system. Flood levels are high and may result in drowning of the Power Station. The high siltation shortens the life span in pipelines and turbines. The recovery of the system depends upon the type of plants that covers the bared areas and this can possibly emphasises proper replanting of trees in exposed areas of the forest.

c) The effects of mining and development causing sendimentation and high suspension in water system meant for Mini Hydro projects.

In Peninsular Malaysia mining industry is extremely active and mining can be in the form of opening of large areas or can be digging up of river beds on small scale by illegal miners. The building of roads and open spaces simultaneously with deforestation have caused large amount of sendiments to appear in the water system. The abrasive nature of the products of these developments are disastrous in the Mini Hydro projects. Controlled mining is necessary to keep the water from being polluted. There is a need to look into the means of reducing sendimentation caused by such activities.

d) Methodology of transport of materials and equipment to site

Transport to site of materials and equipment has been a problem in this area especially during the rainy season. Terrain at times does not allow use of vehicles and the heavily forested area makes it difficult to transport material by means of helicopters. As the cutting of trees is discouraged, methodologies have to be developed for the transport of material and equipment into such areas. Excessive earth movements mixed with the tropical rain can be a hazard.

e) Construction methods using cable systems

From experience, it was found that the best system of construction in this area is using cable systems for transport of pipes, cement, steel and all constructional material necessary at site. The cable system stretches from a convenient location of storage of material and covering the total Mini Hydro system

i.e. from the weir to the Power Station. Methodologies have to be developed considering every site is peculiar in its contours and anchoring methods have to be developed in such cases. Standardised system can be created for all Mini Hydro sites.

f) Type and design of machinery to be used in implementation of projects and the minimum number of equipment that can be used in construction.

In putting up Mini Hydro stations the difficulty in transportation of materials to site means the need to design specific equipment for such system. The number of equipment used in construction should be minimised and if implementation on a large scale is to be carried out, studies into the topic is necessary to cut down costs of construction.

g) The training of manpower for constructional purposes

Working in remote areas having difficult terrain in the tropical jungle, as well as trying to introduce a technology in the remote area, the training of manpower for constructional purposes is essential. The handling of tools and equipment in difficult areas with makeshift construction pads and dangerous situation means the need for such training. The men should be trained for difficult terrain work apart from normal training in constructional methods. The training involves climbing, working suspended in mid-air, working along cliffs, working on river beds, etc.

h) The method of building roads to Power Station.

The building of roads to Mini Hydro Power Stations is not easy due to the terrain and nature of land in this country. There is a lot of experience to be gathered from loggers who build loggers tracks that seem to have lasted for many years. The roads to Power Stations have been thought to cover minimum requirements only, and are subjected to landslides and also the rapid growth of fauna can mean slippery and unreliable roads. The maintenance of such roads can be expensive and as such, the design of such roads have to be looked into bearing in mind that capital spent is small, in order to place project outside the economic constraint of the financing agency.

i) Fitting designs to environment minimising blasting cutting of trees and steps to be taken to avoid danage to pipe lines from fallen trees.

The environmental effect of cutting down trees and blasting of rocks is normally not called for, as disturbances to the environment is highly undesirable in this country. Designs of Mini Hydro systems have to fit to the environment. The cutting of trees have to be avoided and damage to pipelines from fallen trees have to be looked into. The nature of tree falling in the jungle is an unknown phenomena and can be caused by winds, animals or age. Trees close to pipelines seldom damage pipelines

but those further away seem to have more effect. It can be deduced that the height and type of tree and its distance from the pipeline and power station have a strong bearing on degree of damage that these trees can do. Minimising of blasting is essential to cut down the security constraints of construction in such areas in this country.

j) Effect of flooding and generation of electricity while under flood conditions.

In the event of flood occuring it is usually that the wiers and connecting intake area of the Mini Hydro Power Station is covered with water. The tailrace water level at the Power Station rises resulting in overall decrease in head available for power generation. Decrease in head result in inavailability of the Power Station to generate sufficient power and there may be vibrations and fluctuations in the overall system due to this. Power Station foundations are subjected to severe errosion and backwater effect due to constriction of the river downstream from the tailrace. The operation of power station under flood conditions need to be studied as in Peninsular Malaysia floods occur very frequently.

k) Effect of water hammer on pipelines.

Water hammer on pipelines in Mini Hydro systems occur only when the Power Station machinery is subjected to sudden stoppage or due to a sudden closure of the main valves. Water hammer can also occur during the operation of the machine due to the inherent characteristics of the machinery. A study in the effect of water hammer on the pipelines and its solution is essential for the protection of the pipeline and the machinery. Each Power Station is peculiar in this aspect and means of correcting this phenomena is necessary, in order to extend the life span of the Mini Hydro system.

l) Machinery design and seed designs for manufacturing.

In order to reduce costs, it is necessary for countries to manufacture their own turbines where possible. There is a need to produce seed designs as these form a basis for design or other sizes needed. The design of the machinery must take into consideration the capability of the country in terms of local manufacturing especially where precision is demanded. A venture in this area can have vast implications on the future of manufacturing in an undeveloped country.

m) Simplification of turbine governors of load ballast type and electronic types.

Current types of governors, mechanical or electronic are complex in nature and requires skilled workmanship in developing them. There is a need to simplify such governors in order to reduce its cost , bearing in mind also that the degree of precision influences the standard of the electrical power

generated Hybrid designs are recommended and may be a solution to many areas of governor design.

n) Machine transportation, installation and commissioning.

The transportation of machinery to Mini Hydro stations as well as its installation and commissioning demand certain skills.It is essential to ensure that this is correctly done possibly through a system checklist and a guide manual of procedures in handling machinery, checking of levels, dynamic testing, etc. Some degree of training is required in this area especially where larger systems are being installed. The safety aspects of machinery training installation and commissioning must be stressed to avoid mishaps to personnel involved and to ensure long life to turbine and generating machinery. Simplification of the total machinery installation by having the whole power station in preassembled containers is the target. This can be an interesting aspect for study.

o) Fault of generating systems and their protection methods. Computerised control of machine operation, remote sensing for remote operation.

In the long run Mini Hydro generating systems can have faults and in such cases the protection system must be adequate to prevent damage. Where a large number of Mini Hydro Power Stations have been established computerised control of machine operation may be necessary especially in the area of remote sensing for remote operation. This is to cut down manpower as well as to increase reliability of centralized control of these Power Stations as their contribution has a considerable effect on the Grid system.

p) Transmission and distribution designs, Grid connections and reliability of systems.

The transmission and distribution of the electrical energy where the Mini Hydro Station is connected to the Grid can determine the reliability of the total system. Where a large number of Mini Hydro stations are connected to the Grid and they represent considerable value of power input to the Grid, the sum effect of these Stations to the Grid system is large and must be studied from total power generation point of view. Assessment must be made on the reliability of the system, the stability of the system, the effect of faults in large power stations on the operation of these small stations, the effect of voltage swings etc.

q) Social and economic effect of small/Mini Hydro systems.

On the establishment of Mini Hydro power generating system the social and economic effect of the benefiting rural population must be taken into account in order to quantify what was earlier considered as intangibles contributed by such power stations. The social and economic studies will determine the rate of growth

of the area, the contribution of the generating station as a nucleus or development, as well as, the future projections in order to cater for demands of the area. The implication of such a system for rural population must be considered.

r) User of tailrace water for irrigation and drinking water.

Water available from Mini Hydro Power Station i.e. from the tailrace can be used for irrigation or drinking water for the rural population. In each instance study can be done especially on the design and type of water collecting intakes for these purposes. Methodologies to effect these systems must be considered in order to obtain the maximum benefit for the rural area as well as minimising its effect on power generation by the Mini Hydro stations.

s) Pricing of electrical energy when connected to the Grid for economic/financial evaluation purposes.

In evaluating a Mini Hydro station, the pricing of electrical energy must be considered for the economic and financial evaluation of the system to determine availability of the projects and the degree to which the project can recover capital investments injected into it. The pricing of electrical energy is normally inadequately done especially in small Hydro Stations or run river types when these are compared to major Hydro installations. Pricing of the electrical energy transmitted to the Grid must be looked into in order to testify that these Stations prove economical. Methodologies and approach of the pricing system should be laid out so that each country can evaluate its Mini Hydro Stations, as well as, to determine the size of the loan needed from international banks. Proper pricing should also ensure that the benefits obtained are real and will not unnecessarily put a country into debts which it cannot afford. An international agreement on this matter and its approach is necessary . International banks must be convinced of the approach to pricing of the electrical energy generated by Mini Hydro power stations.

t) The effect on Mini Hydro of agricultural development upstream on ungazetted catchment area.

Having installed the Mini Hydro Stations, it is expected that the rural population would increase activities to enhance living standards. There is a possibility that increased agricultural activity will result in development upstream especially on ungazetted catchment areas. The social and economic effect including the effect on the power stations must be looked into, to ensure certain possibilities to be included. In certain undeveloped countries such an incident may not be avoidable, but steps must be taken to ensure minimum effect is seen on Mini Hydro station already built. There may be a need to gazette catchment areas but there is also a need for the rural population to prosper and feed themselves by the use of these areas discriminatingly to ensure that the total ecology and well being

of the catchment areas and the Mini Hydro Power Station is safe from undesirable effects.

u) Types of new Mini Hydro system and research work into these areas.

Innovation and new designs are necessary to produce machinery and systems that can harvest water energy to the maximum. Current designs are limited and can only harvest water designs above a certain head. Research must be done to look into these areas of harvesting water energy to the lowest level and at the highest efficiency. Different turbine designs and new concepts have to considered, as not all the terrain along a river has adequate potential head. Energy in free flowing rivers with no head are enormous but cannot be harvested at the present moment. Efforts have been made to create new engines but insufficient enthusiasm is currently predominant. The aim is to increase the efficiency of the total system with maximum harvest from these rivers.

Priority areas for Joint Research Project

Priority areas should include:-

a) Study into the use and manufacture of the crossflow or Banki turbine for medium and low read Mini Hydro Power Stations

The crossflow or Banki water turbine has been known for many years to be a versatile turbine, easily manufactured, but, unfortunately has a relatively low efficiency when compared to the Franicis turbine or Pelton Wheel. It is known that only one manufacturer has been able to raise the efficiency of such a turbine to value comparable to that of the Francis. This means that it is possible to develop a crossflow turbine that has a high efficiency. The ability of the crossflow turbine to function over a large range of heads as well as over a wide range of flow of water, makes the turbine an essential item in the development of Mini Hydro technology in the developing countries. The fact that the turbine has minimum casting requirements and can be easily fabricated in small Workshops makes it more reasonable for developing countries to venture into the manufacture of this type of turbine. Unfortunately, little work has been by Institutions on the turbine other than those done by private enterprise. It is suggested, therefore, that work in this area be considered to take advantage of the inherent simplicity of the machinery and its capabilities as a Mini Hydro turbine. Malaysia has acquired the designs of the basic turbine from OLADE and is in the process of developing the turbine for use in this country.

b) Joint research into the development of turgo impulse turbine for medium and high head designs.

The turgo impulse turbine is a hybrid and links the

operational field of the Francis turbine and the Pelton Wheel. Castings or fabricated turgo impulse wheel are easily made and this turbine can be developed easily for use in developing countries. The fact that it covers a large range of operation from that of the crossflow turbine to fringe areas of the Pelton wheel operational chart gives this turbine an advantage over the Francis turbine. The complexity of the Francis turbine gives the turgo impulse wheel a definite edge over it. Development of this particular turbine therefore completes the scenario of development required in the turbine area.

c) Research into governing systems for Mini Hydro Stations that includes load distribution, ballast load system.

The governing systems for Mini Hydro Power machinery determines the reliability and standard supply available to the rural consumer. Currently developing governors are based on complex design and there is a need to develop governors either mechanical, electronic or hybrid types for the Mini Hydro turbine. Research into this area can be very fruitful if steps are taken to use alternative parts from tractors and motor car as parts in the governor design. An alternate and appropriate design using available parts would mean low cost development programme for developing countries in this context. Maximum use of these parts should be considered bearing in mind that these parts are available at low cost due to mass production. The use of electronics in the governing system should be minimised where possible as spare parts becomes the issue in the long run.

d) Research into the systems for energy utilisation and use in rural areas such as hot water system, refrigeration systems.

The generation of electrical energy in the rural area would not be helpful to the rural consumer if the energy is limited in use for lighting, radio and T.V. only. As a nucleus of development Mini Hydro energy must be used wisely in a manner to augment the progress of the rural sector. Research into the area of energy utilisation and use in the rural area for hot water system, refrigeration, electrolytic use in agricultural industrial and rural sectors must be considered.

e) Use of water resistance for testing of Mini Hydro turbines.

The testing of water turbines requires loads to be varied over a large range of the water turbine generating systems, loading. The problem of transportation of large banks of resistors for commissioning makes it necessary to use water as a variable resistance representing the loads for testing purposes. Research into the use of water as well as the design of the rigs to create water resistance and the safety aspects can be looked into in order to minimise transportation problems. Current turnkey pojects in the Malaysian Mini Hydro programme makes use of water resistance for loading purposes and it has been found that there is a need to better design and increase safety features.

f) The methods of supply to rural villages using battery charger systems.

For certain developing countries having populated areas very remote from town centres but where a small hydro station can be put up the output from the system may not be able to cater for the number of potential consumers. As such, a method of supplying these areas using the battery charger systems (currently being developed in Malaysia) is being considered. The systems makes use of the concept of storage of electrical energy in batteries. The advantage of this system is the low maximum demand on the generating station as well as its ability to function at long lines at low voltages up to a distance of 16 kilometres. This is an interesting area for research which can mean supply of electrical energy to the rural area for small generating systems, similar to the water supply system where each household maintain a water tank for storage purposes. This method makes possible the combination of a micro hydro system with solar and or wind energy combination or even with a bigas generator. A total integrated system can be adapted where the battery charger system is introduced.

g) Study in maximising the harvesting of water energy.

In a large number of cases in Malaysia where the rural sector has been developed there exist rivers with very good potential for energy harvesting. As these rivers are close to the Grid there is a need to study the means of maximising the harvesting of water energy and transmitting it to the National Grid. Such a Mini Hydro station normally employ induction machines and turbines with no governors. The total concept of the Mini Hydro generating station must be evaluated and researched into to ensure optimisation in terms of capital invested to the project.

Decentralisation of RN-SHP Activities.

The number of appropriate projects can be entrusted to member countries and in particular Malaysia, can be:-

i) Hybrid Governor system, electrical/mechanical.

It is thought that the hybrid governor consisting of a load controller system and a slow speed mechanical governor would be useful in reducing the cost of the governor system. In areas where there is insufficient water, the turbines would be subjected to peculiar operating condition when using a load controller. The pipeline may be subjected to fluctuation of head. It is essential that water must remain at a certain minimum level at the intake to ensure that the pipe is filled with water at all times. The hybrid governor system operates in similar manner to the load controller but the ballast load resistance banks should consist of a short time load resistances able to absorb heat from full load dumping by the generator for a

period of not more than (say) 5 minutes.This temporary load dumping means that the mechanical governor will be able to operate within this period to adjust the machinery inlet valve to the appropriate position. Little demand is made on mechanical unit in terms of time response, as well, as the load resistor banks need not be large as it function only as a short time operating time device.

ii) Micro-processor control of Power Station operation and system protection.

The country is looking forward to building of a large number of Mini Hydro stations for both rural electrification and energy harvesting aspects. Micro-processor control of power system operation and system protection would be essential as it is foreseen in the future that there will be a reduction in manpower operating these plants. There is also a need for centralised control for a group of plants within the vicinity of a control centre. Coupled to this would include the need to conduct research in terms of data, transmission and the remote control of small hydro station to ensure optimum operation of these stations. Low cost solution to these systems are necessary and need to be looked into.

iii) Use of Water resistance for testing of Mini Hydro turbines.

As mentioned earlier under the same title this subject shall be of interest to many countries as it is the means of eliminating the need for resistance banks for load commissioning of the Mini Hydro generating output. The important aspects to be seen in this area is use of high voltage (say 11kV) on the resistance banks can mean excluding heavy equipment to site. The available water at the tailrace or the river bed makes this system suitable for commissioning purposes. The research project should include building the rigs, as well as, determining the configuration and the material to be used. A certain desired standard can be achieved from this equipment.

iv) Development of turbines for local manufacture.

This covers projects that can be entrusted to member countries, as mentioned earlier, as the need to manufacture turbines in order to cut down costs of such an equipment in the developing countries. In particular OLADE design should be considered as a basis for starting.

Available Experts in Malaysia.

As far as Mini Hydro is concerned, the N.E.B's Mini Hydro department is known to have experts in Malaysia and most staff members at the engineering level are competent in many areas. This includes project management, commissioning of power station, designing of power station, reconnaisance survey, computer analysis on Mini Hydro systems, etc.

Consulting Companies in similar line.

The N.E.B has inhouse Consultancy in the Mini Hydro Department pertaining to the subject. The employment of outside Consultants is discouraged due to the nature of work and the cost involved. It is expected in the future that local Consulting Companies would be called to participate and be trained in several aspects of the Mini Hydro technology which has been developed by the Mini Hydro Department of the N.E.B. for use in particular in Peninsular Malaysia.

Equipment Manufacturers.

There are few equipment manufacturers in the country mostly engaged in large scale engineering works. These manufacturers are able to fabricate and design where drawings are available.

Civil Construction Companies.

Large number of civil construction companies have participated in the Mini Hydro programme and are available for construction of Mini Hydro projects.

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Regional Network for Small Hydropower (RN-SHP)

Technical Advisory Group (TAG)
First Meeting

Hangzhou, China, 11 - 13 December 1984

COUNTRY PAPER: NEPAL*

Prepared by

Rabindra B. Shrestha**

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NEPAL - SHP NATIONAL NEEDS AND REGIONAL SIGNIFICANCE

1. Overall Planning

There is still no evidence about the existance of commercially exploitable fossil fuel resources in Nepal. The traditional source of energy being utilized is the firewood. The excessive reliance on forest for energy has created such alarming situation in the country that it may lead to irreparable damage and destruction of water, soil and other basic elements of environment. However, Nepal is bountifully endowed with the one essentially untapped power resource, i.e. "Hydro-power". The estimated theoretical hydro-power potential is about 83,000 MW of which about 27,000 MW could be economically developed in Nepal. However, so far, less than 0.5 per cent of economically feasible potential has been exploited in Nepal.

With a view to pave the ground for systematic development of hydropower in Nepal, three following main categories were being made.

i. Large-scale projects (upto 4000 MW) for meeting the long-term energy need of the country and possibly for multipurpose use and for export of energy to neighbouring countries.

ii. Medium-scale projects (upto 300 MW) are meant for internal consumption in urban areas and industrially prospective locations of midlands and southern Terai plain.

iii. The third category of projects (say upto 5MW) are small-scale projects for meeting the energy needs of remote isolated mountainous regions, as well as for educating the rural people of the region about the practical and multiple use of electricity.

2. Organization

With a view to enhance the development of small hydropower development in Nepal, Small Hydel Development Board (SHDB) - an autonomous Government Board, was created in the year 1975 under the Ministry of Water Resources. The Minister of Water Resources is the Chairman and the Chief Engineer of Electricity Department is the Member - Secretary of the Board. Directly under the Board there is a Central Project Office in Kathmandu, headed by the Project Director. Below this there are five regional offices to co-ordinate and supervise the projects in their respective development regions.

The specific responsibility of the Board is planning, construction and operation and maintenance of small hydroelectric plants in the capacity upto 5MW in the remote and backward hilly areas in the northern part of the country.

3. Project Selection

Compared to other countries of the world the hilly areas of Nepal are quite densely populated. Most of these hills are traversed by large as well as small perennial rivers and generally the village settlements are located quite near to these rivers and rivulets.

For several centuries the villagers have been utilizing the streams for a motive mechanical energy using simple water wheels. But with the construction of few small and medium scale hydroelectric projects in the past three decades, the local population of the hilly area became quite keen and aware to utilize the river potential for the generation of electricity. So recently the demand for the construction of small hydropower stations are coming up from all over the country.

SHDB/Nepal with its limited resources is facing tremendous task in fixing priority for the selection of the project and supply area. At present SHDB/Nepal has the following selection criteria:

i. District headquarters (Nepal is devided into five development regions and 75 districts);

ii. Villages with cottage industries;

iii. Places of tourist interests;

iv. Multipurpose project, i.e. electricity combined with irrigation and water supply.

The funding for the activities of SHDB/Nepal is obtained through the Government of Nepal budget and bilateral and multilateral assistance. So far it has completed 10 projects and currently 20 projects are under construction. The Board has plans to prepare feasibility studies and detailed engineering design for another 10-15 projects within the next 2 - 3 years.

4. Constraints

The number of isolated plants to be considered under SHP programme are numerous and also due to geographic inaccessibility and hydrological conditions of the regions, the following main problems are presently being faced in developing small hydro-electric plants in Nepal:

i. Shortage of technical manpower;

ii. Difficulties of transportation of men and materials due to non-availability of motorable road at site;

iii. Economic and financial constraints;

iv. Large seasonal variation in hydrological regions;

v. Absence of similarity of generating equipments resulting difficulty in operation and maintenance.

5. Needs and priorities identified by National Focal Point (i.e. SHDB/Nepal)

SHDB/Nepal with its ten years of experience in SHP development has identified the following needs and priority subject areas and projects, which are also of regional significance:

5.1 Establish hydrological analysis method suitable for ungauged streams for SHP generation in Nepal

Most of the SHP sites in Nepal are located in the very remote part of the country, and to establish and manage proper (permanent) gauging station in all these small streams is practically impossible. However, without proper hydrological studies, estimates of flow in the river will continue to be in error with the consequent high cost of over- or under-designed hydropower projects.

Therefore, SHDB/Nepal believes an analytical method should be worked out to obtain the hydrological data from these ungauged and partially gauged streams. The analytical method if developed properly could also be utilized by other countries of this region with similar conditions.

5.2 Rationalized design for SHP civil works (Design manual)

SHDB/Nepal has undertaken a number of SHP projects in different hilly areas of the country. The demand for construction of such projects are increasing quite rapidly. SHDB with its limited technical manpower resources is facing tremendous job to cope with the increasing number of investigation and design works.

So, if there are several SHP projects at hand, the design could be rationalized and relatively inexperienced engineer and other manpower could be trained and used in this field.

A rationalized design is one in which design principle and construction details are standardized but the overall sizing is adopted to match the site. Unlike diesel plants, SHP plants cannot be mass produced, each must be designed individually as each site is unique and has its own peculiar problems. Design rationalization will reduce job repetition and consequently utilization of the scarce technical manpower will be maximized. SHDB/Nepal consideres this subject to be also of regional significance.

5.3 Utilization of computer facilities for SHP development

For the ever increasing job of SHDB/Nepal the use of computer facilities are quite obvious. Besides storing a number of different information, it can also help in design computation.

Recently, a research proposal on optimum design system for SHP projects using the computer programme has been submitted to SHDB/Nepal by a local consultant (IDS). SHDB/Nepal is seriously thinking of using computer facilities, especially to also develop point 5.2 above, i.e. design manual.

5.4 To improve the present technical capability of local Electro-Mechanical Equipment Manufacturers

At the moment, only few turbines upto 100 KW capacity have been manufactured locally. Sofar, only crossflow turbines have been tested with the imported generator. Several improvements are required in this field. Collaboration with experienced foreign manufacturer could be very useful.

5.5 To develop economic criteria for selection of most feasible SHP generation - Development of Master Plan for SHP in Nepal.

SHDB has certain criteria and priority for the selection and development of SHP in Nepal. But after electrification of few villages, the demand for electricity in large

number of villages and settlements in the remote hilly areas of Nepal are growing very fast. Taking this into account with the existence of large number perennial streams in the mountains, development of a Master Plan for SHP in Nepal seems to be an urgent necessity.

6. Joint/co-operative research projects

Some of the activities and items mentioned under Section 5. can be incorporated in this Section 6. However, some of the joint/co-operative research projects are briefly mentioned below.

6.1 Electronic Load Controller - ELC

Local manufacturers in Nepal are producing turbines of less than 100 KW capacity, with the imported generators. However, due to high cost, the electromechanical equipment supplied by local manufacturers generally does not include any automatic governor. In Nepal the delicencing policy of SHP projects upto 100 KW has encouraged village community and private entrepreneurs to come forward with more mini hydro projects.

However, in order to implement such programme on a large-scale, it would require cheap as well as reliable electro-mechanical system.

In this context, research project on Electronic Load Controller (ELC), undertaken by the HRC could be quite useful in Nepal. The research project could be further

developed in co-operation with HRC and SHDB/Nepal (local manufacturer).

This item is interrelated with the item 5.4 of Section 5.

6.2 Maximum utilization of local materials - reduction of cement use

As mentioned earlier, most of the SHP projects in Nepal are located in the very remote part of the country where road transportation facilities are not available. Therefore, the transportation cost of construction materials, which is not available at the site is very high. For example, the transportation cost of cement at some sites are 7 to 8 times higher than the actual cement price at the factory.

Therefore, joint research programme could be worked out in the design of hydraulic structure for SHP, where the use of cement can be minimized and the use of local materials can be maximized.

This item is interrelated with the item 5.2 of Section 5.

6.3 Optimum design systems for SHP projects

SHDB/Nepal, at the moment, is considering a research project proposal for optimum design systems for SHP project, submitted by a local consultant (IDS).

The primary objective of the proposed research is to improve the technical and economic efficiency of SHP projects by developing a computer-based design system.

The estimated total budget for this research project is about US$100,000 for three year period. However, the cost and total time could be reduced with the further review of the proposal and availability of specialist manpower in this field.

The most immediate benefit of this research will be the savings in the cost of design and construction of SHP projects. It will provide considerable savings of scarce technical manpower and project time; and also improve technical efficiency by facilitating rational site selection and quality control.

At this moment, this research proposal has not been implemented due to financial and manpower constraints. SHDB/Nepal considers this research proposal useful not only for Nepal, but with some modifications, it can equally be applied to other countries from the region for same reasons as well. Therefore, SHDB/Nepal suggests that this be taken up as a joint/co-operative research project.

7. Decentralization of RN-SHP activities

i. A Seminar/Workshop could be organized on Design of Hydraulic Structure for SHP Projects in 1986 in Nepal, provided that financial resources can be secured.

ii. The SHDB/Nepal would welcome any activity in the future to promote the decentralization of SHP programme.

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COUNTRY PAPER: PHILIPPINES*

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TABLE OF CONTENTS

		Page
1.	Priority subjects	1
	i) Expert Group Meetings	1
	ii) Workshops and Training Courses	1
2.	Priority subject areas for joint co-operative "research" projects	3
3.	Areas and types of activities where the Philippines could take the lead for organizing projects	4
4.	Suggestions to facilitate the implementation of information exchange among member countries	5

1. Priority subjects

i) Expert Group Meetings

a) Assessment of prior accomplishments and present programme

b) Plans and programme for the future (e.g. establishment of a special school for hydropower planning, engineering, etc.)

c) Funding requirement and sources.

ii) Workshops and Training Courses

The Second Meeting of the ASEAN Working Group on Co-operation in Micro/Mini-hydro Development identified the priority areas for its training programme as follows:

a) Technical Planning

- Hydrology
  - Correlation methods
  - Appropriate flow measuring techniques

- Geotechnics (modern)
  - Latest developments in low-cost methods applicable to micro/mini-hydro development.

- Socio-economic aspects
  - Techniques on the determination of tangible and intangible benefits.

- Feasibility study
  - Development of a simplified and standardized format to meet the requirements for decision-making purposes.

b) Construction

- Engineering design
  - Low-cost, simple design utilizing to the maximum content possible locally available materials.
  - Recommendations for the standardization of civil and electro-mechnical works components.
- Contract administration
  - Engineering and supervision
  - Construction
  - Procurement matters
- Local manufacturing capability

c) Management

- Development of effective management systems for micro/mini-hydro programmes.
- Operation and maintenance.

The Philippines feels there is also a need for training on environmental impact assessment and mitigation. Planners and decision makers should be able to identify the critical areas which may be adversely affected by the mini-hydro project and (a) see if something can be done to remedy the effects; and (b) decide whether to push through with the project or not.

2. Priority Subject Areas for Joint Co-operative "Research" Projects

i) Standardization of civil and electro-mechanical works design. The Philippines is currently working on this project, in co-operation with its consultants.

ii) Hydrology - setting up of stream gaging stations; gathering of rainfall and precipitation data; and use of correlation method.

iii) Geology - sub-surface exploration, particularly for the dam, intake, headrace and power plant locations; erosion protection and drainage design for headrace, penstock and other structures.

iv) Diversion Dam - types of dam and criteria for the type of gate to be used.

v) Intake Structure - sediment transport and siltation (maintenance).

vi) Headrace - selection of type of headrace (open or close; steel, concrete or fiberglass).

vii) Surge Protection - design of surge pressure protection for forebay, surge shaft and surge tank.

viii) Penstock - type/material to be used for penstock (steel or fiberglass, etc.).

ix) Power Plant - economical design of power plant using locally available material.

x) Equipment Selection - type and size of mini-hydro equipment units to be used to maximize site potential based on latest performance data.

3. Areas and Types of Activities where the Philippines could take the Lead for Organizing Projects

i) Training

The first and second training workshops on SHP for Asia-Pacific region were held in Hangzhou, People's Republic of China in 1983 and 1984, respectively. A total of twenty six (26) participants from nine (9) countries attended the two (2) training workshops.

Decentralization of training activities may allow to conduct more training courses and workshops in a year. A larger number of people can participate. Some ways in which training activities can be decentralized are briefly discussed below:

a) Holding of training courses outside China.

b) Grouping the member countries by region (or according to certain criteria such as level of SHP technology used, status of SHP programme, etc.); and holding the training courses by region, instead of having all the member-countries participate in every training. This will be more effective since the discussions and examples will focus on areas/problems which are common to the group/region.

c) Establishment of training units, either government agencies or specified groups, in selected member-countries to organize training workshops. One training unit per region/group may be organized which will take charge of the training activities of the region. Training courses may be conducted in different regions/groups simultaneously; they may also be conducted from one region to another (which may be more economical). For example, a group of lecturers may conduct a course in region A. This may be composed of foreign lecturers and experts from region A. The course can be revised to suit the conditions of region B and experts (from region B) can be invited as resource persons.

d) Sub-contracting the training courses to government utilities or specialized groups of member-countries. They may be invited to submit proposals on specific topics. UNIDO/HRC can evaluate the proposal and decide who will conduct the course. The courses can be implemented in the same manner as c) above.

ii) Video Tapes on SHP

HRC has made nine (9) video tapes of its activities for the past years. These tapes have to be reviewed first before work on other tapes can be started. Some scenes/shots from these tapes can be used in future projects. As discussed by the Consultation Mission during its visit to the Philippines, a group of video and SHP experts may be invited to meet and discuss the preparation of video tapes. This group can determine the coverage, the number of tapes, objectives and other criteria/guidelines for the video tapes. Implementation can be done in two ways:

a) Given the guidelines set up during the meeting, HRC can implement the project, hiring video experts as needed. This can be done in co-operation with countries that will be covered in making the tapes.

b) Sub-contract the making of tapes to a member-country or a group of video/SHP experts.

It is recommended that at least three (3) tapes be done at a time. Some shots needed by three (3) films can be taken in the same sites, hence, minimizing travel cost and time.

4. Suggestions to Facilitate the Implementation of Information Exchange among Member Countries

The ASEAN Working Group on Micro/Mini-Hydro Development has set up the MHINEX - Micro/Mini-Hydro Information Exchange System, where member countries are expected to submit quarterly, various data/information

agreed upon during its second meeting. MHINEX (for ASEAN) and other regional organizations can be tapped by HRC to send contributions or other data it needs for its publications. This will entail less time and cost, and may be done more efficiently.

During the meetings (senior experts, TAG, etc.) the participants may agree to submit certain data/information that HRC needs, and the frequency of submittals. A deadline can also be set for regular publications. For example, members should know when they should submit their contribution if they want it to be included in the first quarter issue of the newsletter.